28*th* IUGG Conference on Mathematical Geophysics, June 7-11, 2010, Pisa, Italy
Session 2: Geophysical fluid dynamics II - Sub-surface and surface flows

Onset and dynamic shallow flow of a viscoplastic fluid. Applications to dense avalanches

Ioan R. Ionescu[1], Oana Cazacu[2]

[1]*LPMTM, University Paris 13, Paris , France*
[2]*REEF, University of Florida, Shalimar, FL, USA*

Keywords: *viscoplastic fluids; Saint-Venant flow; asymptotic analysis; safety factor*

The starting point is the 3-D setting of a sheet flow of a viscoplastic fluid. The material constitutive law may include two plasticity (flow/no flow) criteria: Von-Mises (Bingham fluid) and Drucker-Prager (Mohr-Coulomb). A stress analysis is used to deduce a Saint-Venant type asymptotic model for small thickness aspect ratio. The 2-D (asymptotic) model (constitutive law), which relate the averaged plane stress to the horizontal rate of deformation, is not anymore incompressible and represents the plane stress "projection" of the initial 3-D viscoplastic model. The "safety factor" (limit load) is introduced to model the link between the yield limit (material resistance) and the external forces distribution which generate the shallow flow of the viscoplastic fluid from a rest configuration. The discontinuous velocity domain splitting method, developed in [I.R. Ionescu, E. Oudet, Discontinuous velocity domain splitting method in limit load analysis, Int. J. Solids. Structures, 2010, in press], is used to evaluate the safety factor and to find the onset of an avalanche flow. A mixed finite-element and finite-volume strategy is developed. Specifically, the variational inequality for the velocity field is discretized using the finite element method while a finite volume method is adopted for the hyperbolic equation related to the thickness variable. To solve the velocity problem, a decomposition-coordination formulation coupled with the augmented lagrangian method, is adapted here for the asymptotic model. The finite volume method makes use of an upwind strategy in the choice of the flux. Several boundary value problems, modeling shallow dense avalanches, for different visoplastic laws are selected to illustrate the predictive capabilities of the model.